THE EFFECT OF CHANGES IN THE BODY POSITION OF OBESE PATIENTS ON PULMONARY VOLUME AND VENTILATORY FUNCTION*

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It has been demonstrated that a change in position from erect to seated and to the Trendelenburg position results in progressive reduction in the functional residual capacity (FRC) of the lungs in the normal[1] and obese[2] person. This is thought to be caused by elevation of the diaphragm as a result of the pressure of the abdominal viscera. The reduction in FRC has been shown to result mainly from decrease in expiratory reserve volume (ERV) rather than residual volume (RV).[3]

There is evidence that airway closure and air trapping occurs to a greater extent in dependent regions of the lungs, that this takes place even during tidal volume breathing, and that this contributes to abnormalities of ventilation and perfusion.[4] Inequalities in ventilation and perfusion and a decrease in FRC with changes of position are greater in obese than in nonobese persons, presumably because of the compressing effect of adipose tissue on the chest and the greater pressure of intra-abdominal contents on the diaphragm. This study was done to measure the effect of changes in position on pulmonary volume and ventilation in normal and obese persons.

METHOD

Observations were made on 10 obese persons whose average age

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TABLE I. EFFECT OF CHANGES IN POSTURE ON PULMONARY VOLUME*

Subject	*Position*	*IC*	*ERV*	*VC*	*FRC*	*TPC*	*RV*
Normal	Sitting	2.463 ± 0.782	1.182 ± 0.282	3.634 ± 0.814	2.676 ± 0.645	5.134 ± 0.297	1.494 ± 0.123
Normal	Supine	2.770 ± 0.405	0.594 ± 0.135	3.416 ± 0.209	2.175 ± 0.230	4.997 ± 0.231	1.581 ± 0.691
Obese	Sitting	2.363 ± 0.737	0.417 ± 0.089	2.725 ± 0.252	2.045 ± 0.666	4.307 ± 0.313	1.642 ± 0.619
Obese	Supine	2.311 ± 0.735	0.350 ± 0.121	2.663 ± 0.761	1.880 ± 0.162	4.192 ± 1.012	1.642 ± 0.508

*Volume is given in liters with standard deviation.
IC = inspiratory capacity, ERV = expiratory reserve capacity, VC = vital capacity, FRC = functional residual capacity, TPC = total pulmonary capacity, RV = residual capacity.

TABLE II. EFFECT OF CHANGES IN POSTURE ON VENTILATORY FUNCTION

Subject	*Position*	*MMF**	*MEFR**	*FEV₁*†	*FVC*†
Normal	Sitting	3.918 ± 0.699	5.384 ± 0.539	3.066 ± 0.169	3.634 ± 0.258
Normal	Supine	3.375 ± 0.999	5.024 ± 0.109	2.836 ± 0.129	3.416 ± 0.209
Obese	Sitting	3.506 ± 1.245	4.225 ± 1.154	2.411 ± 0.826	2.775 ± 0.771
Obese	Supine	2.657 ± 1.575	3.678 ± 1.513	2.333 ± 0.861	2.634 ± 0.778

*Volume is given in liters per second with standard deviation.
†Volume is given in liters with standard deviation.
MMF = maximum midexpiratory flow, MEFR = maximum expiratory flow rate, FEV_1 = first-second forced expiratory volume, FVC = forced vital capacity.

was 33.6 years (range: 23 to 39 years) and whose average weight was 340 lb. (range: 260 to 456 lb.). Except for exertional dyspnea attributable to obesity, all were asymptomatic and without other abnormalities. Five normal subjects with a mean weight of 140 lb. and mean age of 30 years were studied similarly and constituted the control group.

All determinations of pulmonary volume and ventilatory functions were made while the subjects were seated, and were repeated while they were supine. Volume was measured by the closed circuit helium method. Maximum midexpiratory flow (MMF), maximum expiratory flow rates (MEFR), first-second forced expiratory volume (FEV_1), and forced vital capacity (FVC) were measured with the Godart Pulmotest Spirometer. All volumes and flows were converted to body temperature and pressure saturated with water vapor (BTP). The results are summarized in Tables I and II and Figures, 1, 2, and 3.

RESULTS

In the control group a change from the sitting to the supine position produced a slight decrease in total pulmonary capacity (TPC, 5.134 to 4.997 l.) and vital capacity (3.634 to 3.416 l.), some increase in inspiratory capacity (IC, 2.463 to 2.770 l.), a moderate decrease in FRC (2.676 to 2.175 l.), a marked decrease in ERV (1.182 to 0.594 l.), and little change in RV (1.494 to 1.581 l.). With the change from the sitting to the supine position, ventilatory function in this group showed a reduction in MMF (3.918 to 3.375 l./sec.), MEFR (5.384 to 5.024 l./sec.), FEV_1 (3.066 to 2.836 l./sec.), and FVC (3.634 to 3.416 l.).

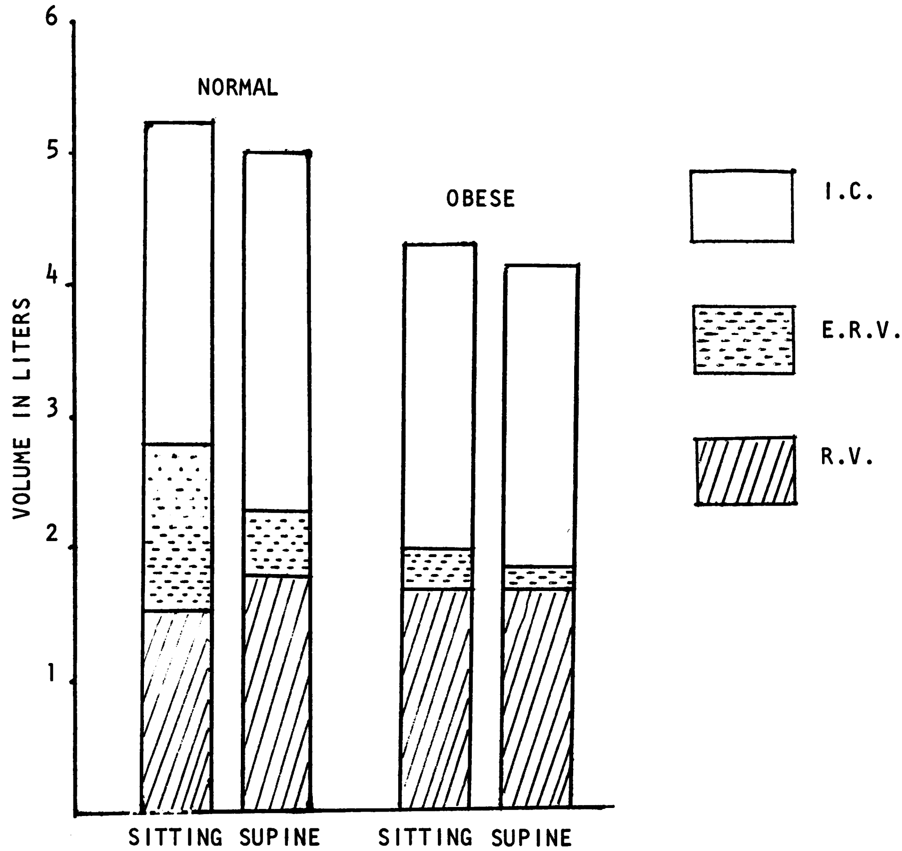

Fig. 1. Postural effects on pulmonary volume and its subdivisions. A comparison of normal and obese subjects. IC = inspiratory capacity, ERV = expiratory reserve volume, RV = residual volume.

In the obese subjects all pulmonary volumes were consistent with a pattern of restrictive lung disease. Altering the patient's position from the sitting to the supine resulted in a slight decrease in TPC (4.307 to 4.192 l.), vital capacity (2.775 to 2.663 l.), IC (2.363 to 2.311 l.), FRC (2.045 to 1.880 l.), and ERV (0.417 to 0.350 l.). No changes occurred in RV (1.642 l.). Ventilatory function in obese patients underwent a moderate reduction in MMF (3.506 to 2.657 l./sec.), MEFR (4.225 to 3.678 l./sec.), and a slight reduction in FEV_1 (2.411 to 2.333 l.) and FVC (2.775 to 2.634 l.).

Discussion

Obese patients are known to display a restrictive lung pattern when

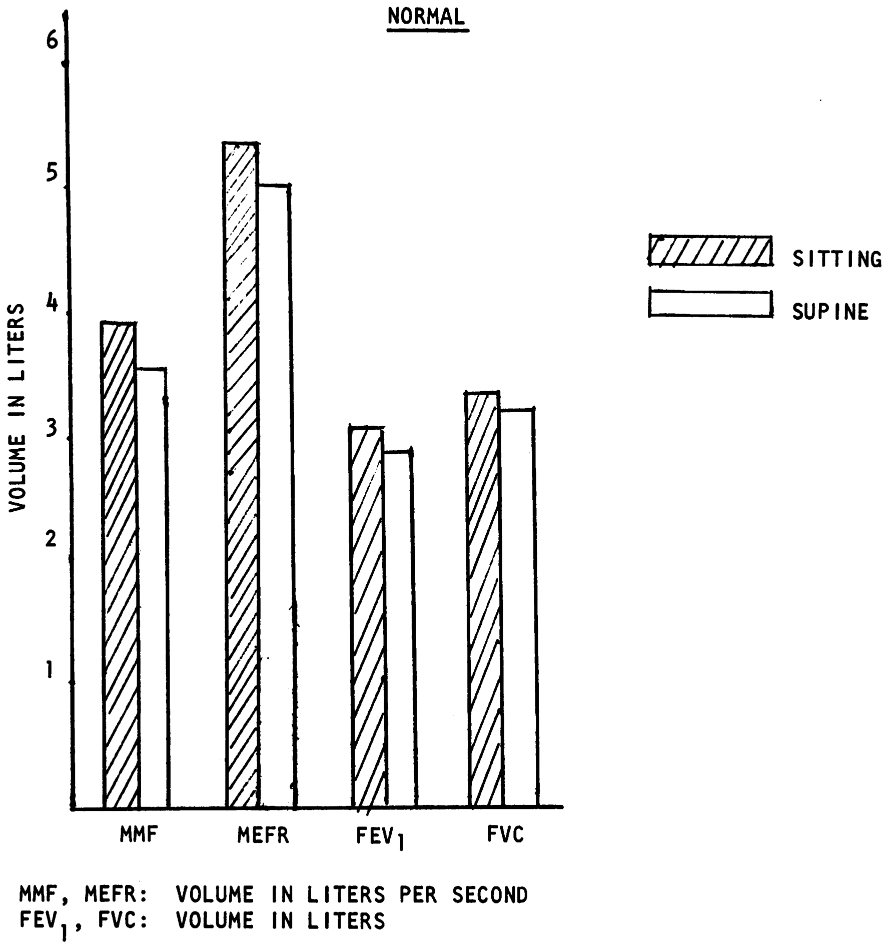

Fig. 2. Postural effects on ventilatory function for normal subjects. For MMF and MEFR, volume is given in liters per second; for FEV_1 and FVC, volume is given in liters. MMF = maximum midexpiratory flow, MERF = maximum expiratory rate of flow, FEV_1 = first-second forced expiratory volume, FVC = forced vital capacity.

pulmonary function is tested. This is thought to be caused by the excessive weight of the thorax and an abnormally high position of the diaphragm, which has been noted by many investigators during fluoroscopic examination.[5] The diaphragm is elevated by the increase in intra-abdominal pressure produced by the heavy abdomen and intra-abdominal contents. Pregnancy, marked ascites, and large, space-occupying intra-abdominal lesions have the same effect on the diaphragm.

We found that changing from the sitting to the supine position

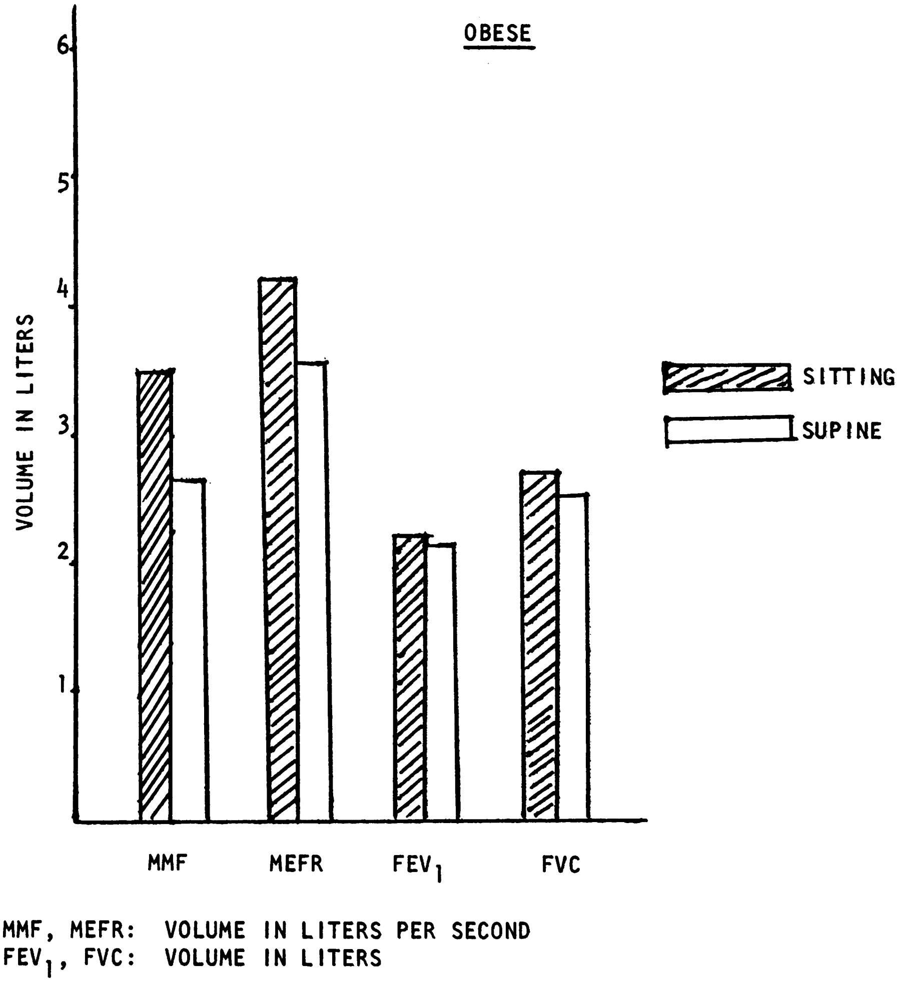

Fig. 3. Postural effects on ventilatory function for obese patients. For MMF and MEFR, volume is given in liters per second; for FEV_1 and FVC, volume is given in liters. MMF = maximum midexpiratory flow, MERF = maximum expiratory rate of flow, FEV_1 = first-second forced expiratory volume, FVC = forced vital capacity.

produced a much larger decrease in ERV in the normal patient than in the obese subject. In the normal patient ERV decreased by approximately 50%, whereas in the obese patient it decreased by only approximately 17%. RV was unchanged in both groups. These findings differ markedly from those of Tucker and Beibert, who reported more than a 50% reduction in ERV in obese patients with change in position from sitting to supine.[2] The difference in our findings may be attributable to the fact that the mean body weight of our subjects was 340 lb., whereas the mean body weight of their patients was 280 lb. As body weight increases, the reduction in ERV in the sitting position increases because of the impediment to movement of the diaphragm which is imposed by adipose tissue, permitting only a slight change in ERV in the recumbent position. We have not yet defined the critical body weight at which the ERV is so reduced by adipose tissue that little or no further reduction can be expected with change in body position.

The change in FRC was attributable mainly to a decrease in ERV in both normal and obese subjects. In our studies FRC was only slightly decreased in obese subjects because of a slight decrease in ERV. RV remained the same with the change in position in both normal and obese patients. Once a minimum thoracic volume is reached perhaps it cannot be further reduced, even by compressive force.

The fact that ERV decreased slightly and TPC remained unaltered when obese patients were brought from the sitting to the supine position explains the small decline in TPC and vital capacity in these patients. Generally, there is a direct relation between pulmonary volume and flow. Consequently, the lowered vital capacity found in obese patients resulted in a decreased MMF and MEFR. The change in MMF and MEFR which occurred in both normal and obese patients with a change in position probably also resulted from the increase in airway closure and air trapping which takes place in dependent parts of the lung.

We selected obese patients who had no history which might point to obstructive lung disease or other pulmonary problems except for obesity. No reduction in timed vital capacity occurred when the patients were brought from the sitting to the supine position. This is evidence that this shift in position did not produce airway obstruction.

Summary

In obese patients a change in position from sitting to supine produced little decrease in ERV. This is in contrast to our findings in normal persons, who showed a marked decrease in ERV with the same change in position. Apparently, in obese people the ERV already is so reduced that an alteration in position can cause little further decrease.

In both the normal and obese persons studied, a shift in position from sitting to supine reduced all measures of pulmonary volume except IC. The reduction in pulmonary volume was a consequence of the

fall in ERV; the decrease in MMF and MEFR was probably the result of a decrease in vital capacity and an increase in airway closure and air trapping in the dependent parts of the lung.

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